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Structure, Activities and Teacher Development in the Philippine Science Teachers' Community of Practice

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Abstract. Effective Science instruction necessitates sustained professional learning, such as through Community of Practice (CoP). Reports about COP in the Philippines indicate varying processes. These are limited to school-based or regional implementation indicating a lack of common CoP understanding. This paper thus intends to describe the structures, activities, and teacher development of CoPs of secondary Science teachers. The study utilized a descriptive embedded multiple-case study design on four exemplary schools nominated by the DepEd Regional offices from the National Capital Region (NCR), Luzon, Visayas, and Mindanao using qualitative data sources. Cross-Case analyses of the interview and focus group discussions revealed that successful implementation of Science CoP requires vital elements of community structure that include visible and active leadership, committed membership, and opportunities for interaction through various forms of collaborative activities. Science teachers' involvement in the CoP leads them to collaborate effectively and professionally, become optimistic and adaptable person, and innovative and goal-oriented facilitators of Science learning. In addition, members of the CoP have effectively fostered camaraderie and built effective working relationships making them more confident, flexible, and motivated individuals, thus aiding their social and personal development.

Keywords: Community of Practice; Professional Learning Communities; Teacher Collaboration

1. Background

The importance of having well-trained and effective Science teachers cannot be disputed in any educational system. This is because Science teachers are at the forefront of nurturing and developing the next generation of innovators and

scientists important in any economy. Training teachers to be effective according to Darling-Hammond et al. (2017) requires features that include "content-focus, incorporation of active learning, support for collaboration, utilization of effective models of practice, coaching, expert support, feedback and reflection, and is of sustained duration. The mentioned features indicate the conduct of professional learning through a community of practice (CoP).

The CoP is based on the idea that learning is done through a social process whereby knowledge is co-constructed in a specific context and embedded within a particular social and physical environment, such as schools (Lave & Wenger, 1991). The concept originated from the study of apprenticeship by Jean Lave and Etienne Wenger in their book Situated Learning: Legitimate Peripheral Participation (1991), where they introduced the situated learning theory. According to this theory, "participation in social practice is the fundamental form of learning" and, as such, viewed learning as "increasing participation in communities of practice." In this theory, learning can happen in formal or informal settings among colleagues in a workplace scenario.

There are three structural characteristics for a community, group, or organization to be called a CoP (Wenger & Trayner, n.d.). First is the notion of a domain of knowledge or general area of interest that provides meaning to the actions of the community. In schools, this may refer to the commitment of teachers towards their interests, discipline, or goals that allows teachers to have content focus, collective participation, and coherence. Second is the notion of community which refers to the group fostering interaction, collaboration, and sharing of ideas for learning towards the domain. When Science teachers collaborate and regularly discuss with a sense of community, they can foster relationships, have collective responsibility, and a sense of belonging that is rooted in trust and respect (Hallam et al., 2015; Gray et al., 2017) and can therefore work towards their domain. The third is a practice that refers to the product of collective learning or the specific knowledge the community develops, shares, and maintains due to their interaction with the domain (Wenger, 1998; Wenger et al., 2002). Practice can be explicit or tacit in forms. Most studies about CoPs had been about developing and implementing tangible practices such as instructional plans and assessment strategies (Lohwasser, 2013; Southerland et al., 2016). Lesser reported are tacit practices such as becoming reform-oriented (Fulton et al., 2011) or the personal, social, and professional development by Bell and Gilbert (1994) based on their three-year study of following CoPs of Science teachers in New Zealand.

CoPs are regarded as valuable for creating social capital (Duguid, 2005) and knowledge management (Aljuwaiber, 2016). In education, CoPs have positively affected teaching practices and student achievement (Dogan & Adams, 2018). It reduces teachers' feeling of isolation, increases sharing of information and resources, promotion of learning and collaboration within organizations by establishing networks and professional alliances (Cardona & Lugo, 2012), promotion of new practices that improve academic rigor, creation of opportunities for instructional leadership (Gerdeman et al., 2018), greater self-efficacy, reduced feelings of isolation, and most importantly the co-construction

of knowledge concerning the teacher's professional practice (Curry, 2010; Woodland et al., 2013) and teachers pedagogical content knowledge (PCK), particularly in STEM (Fulton & Britton, 2011). CoP increased the use of active learning practices of STEM teachers, thereby enhancing STEM learning (Fulton & Britton, 2011; Tomkin et al., 2019). It also has positive implications for instructional resilience, such as during shocks and duress such as COVID 19 pandemic, for it increases social capital, mainly through sharing and co-construction of instructional resources among STEM teachers (Grunspan et al., 2021). It should be noted that there is a direct impact of teacher PCK on student achievement (Kunter et al., 2017; Kleickmann et al., 2013; Gess-Newsome et al., 2017).

CoPs have been used widely as means for the professional development of teachers in many educational systems all over the world to address curricular reforms. In the Philippines, CoP was institutionalized in 2016 and referred to it as Learning Action Cells (LACs). LACs, according to the Department of Education (DepEd) Memorandum, "will become the school-based communities of practice that are positive, caring, and safe spaces" (Department of Education [DepEd], 2016). DepEd described a LAC as "a group of teachers who engage in collaborative learning sessions to solve shared challenges encountered in the school, facilitated by the school head or a designated LAC Leader." The features of LAC are aligned with the framework of CoP. The agenda speaks of the domain of knowledge. Interaction and composition showcase the community, and the learning outputs and activities indicate the practice. The implementing policy of LAC recognizes the value of bottom-up professional learning methods. It ensures that these continuing professional development programs be integrated with government schools' school-based management and school improvement plan.

The implementation of LAC as a CoP came after four years the country shifted from ten years to twelve years of basic education (Enhanced Basic Education Act of 2013). This paradigm utilized the Spiral Progression Approach that requires most teachers to teach at each grade level four main topics -Earth Science, Biology, Chemistry, and Physics. The approach was reported problematic as most schools in the country practice assigning for each class for the entire school year one Science teacher who would teach all four disciplines (Orbe et al., 2018). Teachers, in this case, are struggling to teach content areas outside of their specialization because of the school structure that cannot accommodate four teachers at each grade level in the Junior High School. The findings, for example, of Resurrection and Adanza (2015) revealed that teachers need more time and training to master all the four science content areas, find it challenging to teach without mastery, and do not feel prepared to teach content, pedagogy, and practical activities (Attia, 2017). These, therefore, present a challenge to Science teachers' PCK, which was supposed to be addressed by CoPs through LACs.

However, the USA's Teacher's Know Best report in 2014 provided caution to educational institutions and organizations on implementing CoPs. Their findings showed a higher percentage of negative satisfaction ratings among teachers on CoPs as a form of professional development, with teachers even reporting CoPs as wasted time. The report showcased a need for a better understanding of CoP

structure and implementation strategies as those who indicated negative ratings have also reported poor collaboration in their schools, and those who indicated positive ratings rated their schools to have good collaboration. The contradictory result here may also be pointed to paucity in CoP investigations that explore teachers' natural or spontaneous experiences as they go through CoP. Most investigations have been from studies from a research project or as a school-based intervention (Fulton & Britton, 2011; Abigail, 2016). These studies can only report the contrived experiences of teachers. This is also true in the Philippines, where studies about CoPs are also limited to assessing school-based CoP implementations (Chiao, 2014; Cabral, 2019; Bajar et al., 2021) or regional implementation (Vega, 2020) that provide information on the varying implementation processes, benefits, and challenges of CoPs in the specific locale.

Therefore, there is a need to have a common understanding of what CoPs are and how CoPs contribute to Science teacher development at the national level. Thus, in this paper, we intend to describe the Science CoPs in Philippine schools in terms of (a) structure, (b) activities, (c) factors in its formation and maintenance, and (c) contributions of CoPs to teacher development. It is hoped that the information provided in this article, mainly the key lessons learned, will be valuable for cultivating CoPs in schools.

2. Methodology

This study utilized a descriptive embedded multiple case study approach to describe CoP in the Philippine setting and its contributions to teacher development. In this approach, structures, and composition, aside from the nature of each case, can be given attention (Yin, 2018). Each case is considered a unit of study with subunits of analyses and provides literal replication, thus addressing external validity through direct replication logic. The study mainly employed qualitative data through interviews and focus group discussions. Supporting data comes from a self-answer sheet or questionnaire, particularly in describing the factors in the maintenance and formation of CoPs. Questions however in this self-answer sheet called for in-depth answers and were not necessarily scalable. Having multiple sources of data from multiple cases ensures reliability which allows for checking whether findings are consistent with every case.

The first task in data gathering for this study was the selection of cases done through nomination by the DepEd regional offices where educational supervisors identify schools on mature stages of CoP based on a rubric on CoP Stages of Implementation modified from the Wenger et al. (2002). The school heads from these schools were then contacted to seek permission to conduct the study and to schedule interviews and focus group discussions (FGD) with teachers and the school head.

Only five of the seventeen regional offices in the Philippines participated in the nomination of school cases. There was a total of 6 participating cases. One school was used as a pilot case or case E. Another case (case F) was not considered for not meeting the criterion of the maturing stage of COP based on results from teachers' self-rating and responses from the FGD and interview. Thus, only Cases

A, B, C, and D are reported in this paper, and Cases E and F are not reported. Ratings from the regional supervisors and the teachers of the four cases were consistent on their CoP stage. The ratings indicated that they are committed to achieve common goals and know about each other's approaches. They have a learning agenda and standards for recurring problems, and have developed, organized, shared, and utilized explicit knowledge products based on their agenda.

The four cases are representative of the national capital region and the three main island groups of the Philippines – Luzon, Visayas, and Mindanao. During the time of the conduct of the study, Case A has 14,000 students with 70 Science teachers, Case B has 5,000 students with 32 Science teachers, Case C has 1000 students with 3 Science teachers, and Case D has 4084 students with 27 Science teachers. All schools excel in their respective divisions in terms of student competitions. Case A, B, and Case C had won international student science research competitions. Participants per case include their principal or school head and teachers. There were 9, 13, 3, and 11 participants in Case A, B, C, and D respectively. The Science specializations of teachers are relatively well distributed in all four participating schools. In terms of average years of stay with the school, Case B teachers have been the longest, with a mean of 12.5 years, followed by Case D with 7.4 years, Case A with a mean of 3.75 years, and Case C with 2.25 years.

Interviews and FGD in the four schools were done face to face, while in one school, it was made through video conferencing due to COVID-19 restrictions. Participants of the study were informed about – the purpose and background of the study, that their participation is voluntary, they can withdraw anytime, the risks and benefits from participation, and the roles of the researcher and participants. Participants who were willing were requested to sign the letter of consent. The participants were then asked to answer a survey that included how they maintain their COPs and rate their CoP stage of development. Lastly, participants who were administrators were interviewed, and Science teachers or members of the CoPs were asked to participate in an FGD. Questions asked to them include: (1) How has pursuing interests, goals, and projects together helped you become better as a science teacher? (2) Do your interests and goals as a community or group change How? (3) Have your interactions and engagements with co-teachers changed over time? How? And (4) What do you think in general are the contributions of CoP to being a science teacher?

The interview and FGD were audio and video recorded, transcribed verbatim, and translated into English. Both verbatim and translated transcripts were sent to participants prior to analysis for checking. Audio transcripts were analyzed using Braun and Clarke's six-step thematic analysis method (2006). Responses were coded and organized into themes and meaning units per case and cross-cases. Case reports were then prepared for each case indicating qualitative themes and were sent to participants for checking once again. Cross case report is then followed by synthesizing data from cross-reports. The report incorporated the responses of respondents on a self-answer sheet questionnaire which were ranked to emphasize the prioritization of CoP maintenance activities.

3. Results and Discussion

This section shall describe the structure, composition, and CoP activities across four nominated cases.

3.1 CoP Structure & Composition

Interview and FGD data from all four cases indicated that Science teachers worked as a CoP much earlier than the establishment of LAC in 2016. The formal structure, however, started with LAC establishment. Table 1 presents the cross-case report of the typical structure and composition of Science CoPs with corresponding roles of members reported by participants of the study.

Table 1: Composition of Science CoP

Personnel	General Responsibilities
Principal	Formulates Vision Provides funding for CoP Support CoP undertaking through attendance
Department Head	Supervises schedule of teachers for instruction Directs teachers to implement CoP activities Provide resources for research Supervises classroom observation Directs the implementation of annual Science activities Supports fellowships
Science Program Coordinators	Supervise all activities under his or her care both in instruction and learning Remind all Science teachers of documents for submission
Master Teachers	Serve as content-specialists for mentoring or coaching Plan and coordinate monthly LAC sessions Plan and coordinate in-service trainings Prepare report for CoP activities
Proficient Teachers	Participate actively in all Science activities Meet with master teachers to discuss difficult competencies and sharing of techniques.

The Science CoP structure conforms with the formal organizational structure of schools in the Philippines. This includes the principals as the head and the department heads who supervise the school science teachers together with coordinators. Those having ranks of Master teacher and higher mentor the newly hired or lower-ranked Proficient Teachers. The formal structuring of CoP among the cases indicates the importance of the leadership of the principal and the department head in establishing the agenda and direction of a CoP.

3.2. CoP Activities and Factors in CoP Formation

The identities of the four CoP cases were established through their interactions and engagements, particularly through their participation in the regular activities that they established. Teachers reported that these activities were collaborative and provided means for them to share and develop their practice. These activities vary for each school as presented in Table 2. It should be noted that the table only includes activities set up by Science teachers' CoP and tasks that are intended for the school-wide teaching force are excluded in Table 2.

Table 2: CoP Activities Across Cases

Area	Case A	Case B	Case C	Case D
Agenda	Least mastered competencies, pedagogy, self-development, stress management, and assessment.	Least mastered science learning content, pedagogy, and ICT integration.	Least mastered Science content and coordination of activities	Topic: Science content, sharing of best practices, strategies, instructional materials
Activities	1. Grade level seminar-workshop sessions (Weekly LAC session) 2. Weekly mentoring session (1 Master teacher assigned to mentor 3-4 grade level teachers for learning content). 3. Monthly Lesson Study 4. Facebook group chat messaging 5. Research groups	1. Science Grade Level seminar-workshop (Monthly LAC session) 2. Teacher initiated mentoring 3. Facebook group chat messaging	1. Coaching, informal discussion, and coordination of schedule and activities over lunch (Daily informal LAC session) 2. Team teaching 3. Facebook group chat messaging	1. Science Grade Level seminar-workshop (Quarterly LAC session) 2. Facebook group chat 3. Action research groups 4. Teacher initiated meetups

It can be seen from the table that Case A has the most structured approaches among the four cases, which is commendable for a population of 70 Science teachers. Their LAC sessions are done weekly and by grade level, where teachers take turns being resource speakers based on their agreed agenda. Their weekly mentoring sessions are targeted to improve science instruction. Master teachers who specialize in the content area of a given grading period in a particular grade level are assigned to three to four teachers to mentor them. Case A is the only case among the four that conducts lesson study. They said that teachers develop together a lesson plan that they are to implement within a school year in their monthly lesson study. Case A also has developed groupings meant to coach students for Science fair competitions. In addition, they communicate via group chat and meet daily in their shared offices.

For Case B, formal LAC sessions are done monthly, by grade level, and organized by the master teachers. The science teachers also initiated mentoring sessions to help each other on Science content topics they are not confident in teaching. Proficient teachers organized their schedules with their master teachers for these sessions at their learning centers. Their group chat was beneficial for them to communicate with each other easily because they are in separate buildings and have no shared office.

In Case C, LAC sessions were informal and were done every lunchtime according to the teachers. They were only three Science teachers in their school, so it was very easy to coordinate with each other on activities and mentor each other. It was also easy for them to set up team teaching. They can arrange their schedules so that for grading periods with Science topics outside of their specialization, either they swap with another teacher or seek help to co-teach with another teacher. This is due to difficulty teaching Science content topics expected to their current context and structure.

In Case M, formal LAC sessions are done quarterly, arranged by the master teachers with topics prepared and selected prior to the start of the school year. According to teachers, their LAC session is output-based. The Science teachers also had action research groups where teachers would implement proposed learning strategies in their classes. They also reported having meetups or discussions about work over coffee. They also said that they do mentoring during these sessions.

It can therefore be said that the Science teachers from four CoP cases are highly engaged with each other on activities that are mandated by the DepEd and on activities that they themselves organize. Attendance to LAC sessions and mentorship of Master Teachers have mandated programs. For example, these are included in the assessment for teachers' performance rating that prompted teachers to participate. Group chats, research groupings, and other group-initiated activities, on the other hand, are non-mandated with no equivalent ratings but are still well participated, which indicates the desire to build relationships and foster learning in their respective schools.

Information presented about CoP activities was supported by a survey about how CoPs were maintained. Results are shown in Table 3 with the corresponding rank average per school and across cases. The following discussion incorporates the responses from FGD and interviews of teachers and school administrators.

Table 3: Comparison of CoP Maintenance Activities Across Cases

CoP Maintenance Features	Rank average per item				Overall Rank Equivalent	SD
	Case A	Case B	Case C	Case D		
Attend meetings of the group and participate actively during the discussion	1	3.5	4	1	1	1.60
Designate committee heads or coordinators for tasks that are complex such as school science programs	3.5	6.5	1.5	4	2	2.06
Initiate or propose activities for the group that is worth undertaking.	3.5	8	1.5	4	3	2.72
There is a leader who facilitates the formulation of vision, goals, and strategies that sets the direction for science learning and instruction	7	3.5	4	4	4	1.60

CoP Maintenance Features	Rank average per item				Overall Rank Equivalent	SD
	Case A	Case B	Case C	Case D		
There is a leader who programs class schedules to ensure time for each other for meetings.	3.5	1	6.5	9	5	3.49
There is a leader who addresses teachers' needs, such as rooms, equipment, and other tools that teachers need during meetings, trainings, workshops, and research activities.	8.5	6.5	4	2	6	2.84
Being responsible for producing outputs required, such as learning resources for the group on time	3.5	3.5	9	6.5	7	2.66
Refer to minutes of meetings and other documents when planning for science activities in the school.	6	3.5	8	8	8	2.14
Utilize data as basis for reviewing and planning instruction.	8.5	9	6.5	6.5	9	1.31

The four cases consistently prioritize their attendance at meetings and actively participate in them. In Case A, for example, teachers said that they respect their leaders and coordinators, so they make sure they attend whenever there are meetings. In Case B, they attend informal meetings most of the time. According to their principal, for Case C, the teachers meet every lunchtime and are very cooperative. However, for Case D, the teachers attend meetings because according to them they are obedient and have no choice. This shows that despite being compelled, teachers are committed to their goals. According to Hord (2009) and Tam (2015), this sense of membership is essential in CoP as this leads to the commitment of teachers to a learning community.

The four CoP cases also have consistently placed designating committee heads or coordinators as one of the top activities in maintaining their CoPs. All four cases have designated coordinators, specifically for their LAC sessions and other tasks. Cases A, B, and D have grade-level coordinators for the LAC sessions, while Case A has specific subject specialist master teachers for mentoring sessions. Case C LAC involves all the three teachers to discuss informally, but they each agree on particular assignments to coordinate tasks such as the areas of student research. One teacher is assigned for robotics, another for life sciences, and another for physical sciences. This indicates that in the CoP cases, there was an observed distributed leadership that, according to Leclerc et al. (2012), can provide better coordination among tasks, leading to teachers seeing the value of their contribution and CoP itself.

They are also consistent with initiating and proposing activities for the group. In all four cases, teachers indicated that they proposed activities that the administrators supported. In Case A, for example, their principal noted how dedicated the teachers were by proposing activities such as environmental clean-up drives or even submitting a proposal to the mayor's office for funding; in Case C, the teachers proposed space shows and robotics training; in Case B, the teachers

initiated their mentoring sessions; and in Case D, teachers came up with their action research groups. These are just some of the activities teachers initiated in their CoPs. Doing these activities can create what Wenger et al. (2002) termed as rhythm, which they found to be present in successful CoPs and proposed to be a principle for cultivating CoPs. Rhythm is having a balance of activities and correctly pacing them to allow the community to thrive and remain vibrant.
The four participating CoPs are also consistent in utilizing data as the least practiced activity. Case A teachers were required to conduct item analysis as a basis for instructional improvement. However, teachers did these individually and were not used as a basis for discussion in the Senior high school since they teach different Science content for different tracks. Case D made use of data as well for decision-making. They accordingly used data to transform their instruction following low achievement scores in the National Achievement Test. Data were also used in identifying least learned competencies as the basis for the preparation of strategic intervention materials for both Case C and Case B. The teachers, therefore, utilize data for decision-making but not as significantly enough as they do this individually.

It should be noted that the Professional Standards for Philippine Teachers (DepEd Memo 42, s. 2017) also stipulates that data-driven decision making be standard practice. It has even included the exploration of data collaboratively to improve instruction and practices as indicators of highly proficient and distinguished teachers. In Gepila's (2020) study, teachers assess themselves to be proficient only in assessment and data use . This indicates that teachers' use of assessment and data is for their classroom only and is not shared and discussed with peers. Such a result of Gepila is consistent with the results presented in Table 3. CoPs are supposed to help utilize data for instruction according to the United States Department of Education [USDE] report (2010). However, this required administrative support, collaborative structures, and time for teachers to discuss within workweek. Abbot and Wren (2016) suggest having specialists or experts mentor teachers to utilize data for instruction. Thus, a structure for discussing data and assessments should be embedded in the CoPs.

The four schools vary in their responses on being responsible for producing outputs or learning resources on time. For both Case A and Case B, this item was among the top observed practices, while for both Case C and D, this item is at the lower end. One good reason for this is that the department heads described by both Case A and Case B teachers were supportive. Case A teachers even said that their chairperson is very organized and that all they need to do is comply, which is also why they respected her. This characteristic of the department chairperson is the opposite of what was mentioned in Case D. In Case C, teachers do not have a chairperson. They only need to answer to their principal directly, which indicates that they do not need to rush. Another reason for Case C is that, since there are only three of them to work on tasks equivalent to six teachers, they do not have much time to produce learning resources on time.

The other item with high deviation has a leader who organizes teaching loads and schedules for meetings. This is similar to the scenario in the previous paragraph.

Cases A, C, and D have department chairpersons who prepare schedules, while Case C is their guidance counselor. For Case D, there was no common schedule for teachers to meet. This is also evident in the frequency of interactions in Case D compared to Case A and Case B. The teachers in Case A have bi-monthly to monthly LAC sessions for LAC sessions on average. Case B has four times in a grading period, whereas, for Case D, it is only once per grading period, or once every two months.

The other item not consistent in the four cases refers to minutes and documents when planning for activities, which again scored among the top observed practices for both Case A and Case B. However, there is least for Case C and D. This could again be due to the characteristics of the chairpersons of Case A and B as being organized. Regarding Case C, they said that they do not have minutes as most of the time, their daily interactions cum LAC session cum meetings were done informally over lunch.

With what was presented, the following insights are drawn:

1. Active participation in meetings and activities need not require the imposition of a memorandum like that for Case D. What is necessary is the frequent, more structured, and well-supported CoP activities through the leadership of both the principal and department head like in Case A.
2. Having a leader who programs schedules to ensure time for each other and for meetings supplements the lack of shared office space, such as in Case B.
3. New CoPs without formal structure but have shared goals still work. They can frequently meet to propose activities worth undertaking and designate committee heads for complex tasks. These maintenance activities helped develop a sense of community that is lacking, such as in Case C.
4. Current CoP cases in the Philippines are not data-driven; thus, support is highly needed in this area.

Data drawn from the interview and FGD of the four cases points to three main factors in the formation and maintenance of CoPs. These are presented in Table 4.

Table 4: Main Factors in Formation and Maintenance of CoPs

Factors/Implementation	**Case A**	**Case B**	**Case C**	**Case D**
Leadership	Management of principal and supervision of Department Head	Management of Principal and supervision of Department Head	Management of Principal	Management of Principal
Sense of Membership	Good relationship and commitment towards goals	Good relationship and commitment towards goals	Good relationship and commitment towards goals	Good relationship and commitment towards goals
Opportunities for Interaction	Frequent due to shared office	Dependent on CoP activities and proximity of homerooms; lack shared office	Every lunchtime at the clinic	Dependent on CoP activity; lack of shared office

The first factor reported across cases is leadership. All the principals in the four cases provided the necessary support to the teachers, of particular interest mentioned as providing resources for the student research and competitions. However, the leadership of the Science department head has more impact in terms of CoP. In Case A, for example, the department head pushed the members to collaborate. Important characteristics of department heads cited in Case A and Case B are described during the FGD, which included being caring, organized, and supportive. On the other hand, the Case D chairperson was described as someone who does not go out of their comfort zone and is unsupportive, leading the department not to advance. Leadership therefore in the context of CoP is vital as it contributes to better coordination of networks and communication flow, resulting in active participation and an increase in knowledge flow among members (Probst & Borzillo, 2008; Zanjani & Alami, 2009).

Second is the sense of membership which includes aspects of commitment towards their goals for Science learning, professional growth, and collegial relationships. Sense of membership can be observed in both old CoPs such as Case B and newer CoPs such as Case C. This finding is consistent with Pyrko et al. (2016), which stated that CoP development involves creating a new link between finding the meaning of learning together and the sustainability of thinking together.

Lastly are the opportunities for interaction which vary mainly across cases due to not having dedicated time for interaction and not having a shared office space. However, teachers compensated for this with their teacher-initiated meetups, online group chat, and other teacher-initiated activities. Having such regular opportunities allows members to think together which is necessary in CoP based on the findings of Pryko et al. (2017).

3.3 Science Teacher Development

This section presents the positive changes Science teachers experienced from their participation in CoPs. This part is anchored to the teacher development model of Bell and Gilbert (1994). According to Bell and Gilbert, CoPs lead to three aspects of development among Science teachers, namely Social Development, Personal Development, and Professional Development. The experience of social development starts with the realization that isolation is problematic and ends in working comfortably with colleagues. On the other hand, personal development changes teachers' experience in their perceptions, attitudes, and beliefs about what it means to be a Science teacher

Lastly, the professional development of the teachers refers to changes teachers' experience through CoP that led them to become empowered Science teachers that includes desiring change, experimenting with methods, and then embracing the change (Bell & Gilbert, 1994). The study of Bell and Gilbert was done by observing how teachers work together through a research project for three years to capture teachers' development. However, in this study, data comes from interviews and FGD, which intends to capture teachers' experiences from natural and spontaneous CoPs. A summary of the results of teacher developments is presented in Table 4.

Table 4. CoP Contributions to Teacher Development Across Cases

Development Aspect	Case A	Case B	Case C	Case D
Social Development	Friendliness Help-seeking	Friendliness Help-seeking	Patience Comfortable with peers Help-seeking	Patience Listening skills
Personal Development	Confidence to teach Control in the classroom Staying motivated to teach	Confidence to teaching and handling responsibilities Staying motivated to teach	Coping stress	Staying motivated to teach Flexibility Social identity
Professional Development	Innovativeness Increase of personal instructional standards	Innovativeness	Increase of personal instructional standards	Goal-orientedness Efficiency Openness to input and feedback

Social Development. The report of the participants has indicated genuine experiences of social development. The first aspect reported is how teachers could get along well with peers. For example, in Case B and Case C, the teachers mentioned learning to get along, opening to others and being open to each other, and adjusting to each other's personalities. Getting along well and adjusting well with peers is essential because it makes collaboration easier, which is necessary according to Case A teachers. After all, they need manpower.

Case D teachers also reported developing listening skills from their interactions with each other which is important to know their colleagues better. Teachers also reported improving their patience, learning to listen, and learning to handle and adjust to peers who at times are irate or moody. Another change observed was having a stronger bond that accordingly leads to being able to ask for help from peers, such as in Cases C and D. In case B, teachers do not even have to ask to be helped as they have developed in time an unwritten relational understanding when a peer needs help.

The responses of participants as regards to their social development can therefore be put in a continuum. This means that the participants, just like Bell and Gilbert (1994), realized the necessity of getting along with peers by adjusting to each other's personalities, which required listening and being more patient. Through these, they have become more comfortable with each other, that they can seek help and give support every time they need each other.

Personal Development. Responses from the participants indicated that there are indeed personal level changes, including coping with stress, gaining confidence, control in the classroom, and having an identity. First is the handling and or coping with stress. Teachers of Case C, for example, had a chat and open forum or feedbacking sessions as means to calm them down and help them handle situations involving classrooms, peers, and students. Though heavily loaded with

teaching assignments, their warm interactions and relationship allowed teachers of Case C to handle stress better. This was particularly observed by a teacher who had experienced being the sole Science teacher in her previous school assignment. No one else could relate to what she went through as a Science teacher.

Another change that teachers endorsed was control in the classroom, particularly in Case A. One teacher in Case A reported that she used to break down resulting from not knowing how to handle her students. She acknowledged that she could not handle her class as a mature person like her colleagues. From there, she received help and support from her colleagues and realized to accept challenges in the classroom and make an effort instead of getting frustrated and complaining about her students.

Another personal level change that the teachers experienced in Case D was being able to have an identity. Teachers particularly described it as having roots and belonging to a family. One teacher even said that he felt more effective if he belonged to particular norms or groups. Another described having an identity as a feeling of not being the only person struggling. Teachers added that some identities of science teachers include being more organized and using more teaching tools when teaching than teachers of other subject matter.

Participants also reported developing confidence in CoP. One experience of Case A had a new Science teacher who lacked the experience in teaching Science. Her colleagues in the CoP provided the necessary encouragement and support for her to teach Science. In summary, the constant interaction and feedback from CoP led teachers to realize they need peer support leading to control and confidence in the classroom and the development of identities as Science teachers.

Professional Development. In terms of personal development, teachers reported having clearer goals, increased teaching standards, and becoming innovative. First, teachers reported that CoP led them to have clearer goals of producing Science literate learners. They said that if they were alone, they would have wandered. Second is the increasing the standards for Science teachers, which is evident in the teachers' desire to change. Teachers have reported particularly, in case C, that being surrounded by the best teachers influences them to be better. They were also inspired to stay current or updated on recent advances in Science, saying they wanted to contribute much like their colleagues. Case D teachers have also reported becoming more open to input and feedback from knowing their peers' performance through CoPs.

Another form of professional development was exploring new ways to teach a particular topic. In Case A for example, teachers used to have typical culminating Science activities but changed it recently after their deliberation in their CoPs. They even had another plan for the succeeding year on tranforming trash into something more useful. In Case B, teachers utilized of hands-on and student-centered approaches and integration of ICTs that stems from their CoPs observation of students who easily get bored in the class. In both cases, CoPs allowed teachers to collectively reflect on their current practice and not just

remain comfortable with the status quo, hence, invoking to practice innovativeness.

These findings are consistent with the review of Dogan & Adams (2018) that CoPs can lead to positive teacher practices as CoPs allow facilitator support and collaboration, promote active learning strategies, focus on instruction and students, and reflective dialogue. In addition, the participants' responses provided evidence that CoP contributed to the social, personal, and professional development of science teachers. This also supports the model of Bell and Gilbert (1994), indicating that the three aspects of development are interactive and interdependent. As mentioned earlier, the personal development of the teachers was enabled by their social development. Both personal and social development precede professional development, as purported by Bell and Gilbert. Being reflective and the increasing standards of teaching are indications of professional development but arriving at this point required the teachers the social interactions afforded to them by their membership in the CoP that allowed teachers to be comfortable with each other, confident when interacting with peers, and is open and empowered by seeking help.

This study thus agrees with Bell and Gilbert that professional learning programs of teachers should involve not only the implementation of suggested activities by the teachers in their respective classrooms but also must consider the personal or social aspects which are often underplayed. This also explains why professional learning that features content focus, active learning, collaboration, coaching, feedback and reflection, and sustained duration is effective (Darling-Hammond et al., 2017). This is because having professional learning that is both sustained and collaborative enough could lead to the development of teachers' personal, social, and professional development.

4. Key Lessons Learned

The following key lessons learned are derived from the presented results that can provide inputs for CoP cultivation in schools.

a. The significant roles of the principal in CoP include setting the vision, establishing mechanisms for teacher collaboration, providing the funds and resources needed by teachers for their professional growth, and formulating policies favorable for Science instruction and learning.
b. Department heads directly impact CoPs as they are the ones who organize and encourage teachers to collaborate, provide immediate assistance, and monitor implementation. Teachers prefer them to be caring, systematic, and supportive over qualities that limit teachers' potential.
c. Being a member of a CoP requires a commitment to pursuing goals and maintaining a good working relationship.
d. CoP teacher engagements and productivity are highly dependent on workload, schedule, and shared space.
e. Participation in CoPs can lead teachers to become driven by higher standards, innovative, reflective, flexible, confident, optimistic, motivated, patient, and friendly. This is because teachers can see models of performance and character from peers through their frequent engagements in CoP.

f. Planning for activities before the school year is vital to identify activities that Science teachers will pursue in their CoPs.

5. Conclusion

Based on the four cases, Science CoPs in the Philippines are governed by a DepEd memorandum requiring schools to establish LAC. Science CoPs follow a typical school organizational structure with principal and department heads as leaders and master teachers as mentors and coordinators to Proficient or new teachers. Leaders together with members work as a community in setting up learning structure that fosters sharing and co-construction of practice through mentoring, coaching, team teaching, LAC sessions, and other group initiated activities such as group chats and meetups. Three vital elements of community structure led to the formation of CoPs, namely leadership, a sense of membership, and opportunities for interaction which are at the same time contributory to maintaining the CoP in the participating schools. The maintenance activities include active participation in CoP activities, programming schedules by department heads, forming committees for complex tasks, and proposing Science activities. On the other hand, the least prioritized activity is utilizing data for reviewing and planning instruction as a group. The lack of fellowship made attendance and participation in meetings a form of compliance rather than a willful act borne out of mutual respect among members and to the leaders of the CoP. Involvement in Science CoP can lead teachers to become innovative and reflective and aim for high professional teaching standards. Socially, they effectively fostered camaraderie and built effective working relationships making them more confident, flexible, and motivated. The study, in general, has provided evidence of total Science teacher development through participation in CoPs that are beneficial for student learning. Therefore, schools and teachers can learn from the structures, learning activities, and maintenance activities presented in this paper to cultivate or improve their current CoP. Further studies focusing on impact of CoPs on Science teaching practice, innovations and PCK are recommended.

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